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SOME CHARACTERISTICS OF A SHELTER BELT AT THE GLASSHOUSE INVESTIGATION UNIT, AUCHINCRUIVE, AYRSHIRE (PART 2)

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INTRODUCTION

The shelter belt of ICI "Paraweb" at GIU Auchincruive was extended to a height of 3.5 metres. In Ag Memo No. 821 the effectiveness of the original shelter belt was investigated for winds from between SW and SE. In this report the winds from all directions are considered in order to test the effectiveness of the heightened shelter belt, and also to discover what happens when the wind is from the North or the East. An attempt is also made to discover what occurs at the ridge height of the glasshouses.

SITING OF ANEMOMETERS

A plan of the glasshouse complex and the wind break is shown in Fig 1. Six cup counter anemometers and two cup contact anemometers were set up to record the wind speed at various points within the complex and outside in the open. One cup counter anemometer was placed beside the plastic tunnels (A and B in Fig 1) approximately 34 m from the western wind break. Four cup counter anemometers were placed in a row between two sets of glasshouses aligned E-W. The distance between each of these anemometers was approximately 20 m with the anemometer nearest to the wind break being approximately 14 m away from it. The sixth cup counter anemometer was sited in the open to the south of the complex approximately 28 m from the shelter belt. All the cup counter anemometers recorded the wind speed at a height of 2 m.

The cup contact anemometers were used to record the wind speed at higher levels. One was placed on the corner of the packing shed roof (Fig 1) and the other on the ridge at the end of house 12 (Fig 1). The ridge height of the glasshouse is 4.7 m and it is at a distance of approximately 21 m from the SW edge of the wind break. The packing shed is approximately 82 m from the western wind break.

DATA ACQUISITION

The staff at GIU Auchincruive read the run of wind from the six cup counter anemometers each day at 0900 GMT and changed the chart each week on each of the recorders for the cup contact anemometers. Readings were obtained from 16 December 1977 to 30 April 1978. The main wind direction for each day was taken from the hourly wind tabulations at Prestwick Airport which lies approximately 2 miles NNE of the site at Auchincruive.

Unfortunately once again the cup contact anemometers did not provide satisfactory results throughout the period. The batteries did not hold the charge sufficiently and in the end it was discovered that only one battery could be used. It was decided to concentrate on the results from the anemometer on the glasshouse ridge and forgo any results from the anemometer on the packing shed roof.

RESULTS

The ratio of wind speeds from inside the complex to those outside was calculated for each day for each of the inside anemometers. Each ratio was then allocated to a North, East, South, or West quadrant according to the main wind direction for the day. The data for 11 days were not used in the investigation as the wind direction was too variable to enable a particular direction to be allocated to that day.

The run of wind measured in the open was taken as the standard wind for the day, and a division was made of days with run of wind greater or less than 200 miles per day. An analysis was then completed on a) all winds, b) winds less than 200 miles per day and c) winds less than 200 miles where there was a sufficient number of events in b) and c) for each direction to make analysis feasible. In most cases there was no significant difference between ratio mean values with increased wind speed therefore all speeds were considered for the main analysis. For the winds at ridge height sufficient data was obtained to analyse winds from West and South only. A mean value of the ratio for each wind direction was calculated. The results are summarised in Tables I to III.

At site 1, in front of the polythene houses, the reduction in wind speed varied between 53% with winds from the North and 43% with winds from the West (Table I). A 't' test was applied to the mean values of Table I and there was found to be no significant difference between the means for different directions at the 5% level of significance. The upper 95% confidence limit of the mean values were all less than 1. A mean value was then calculated using all occasions including the 11 occasions of variable wind direction and the reduction in this case was 46%.

The existing buildings provide shelter to this site from winds from North and South. The anemometer is 10 times the height of the barrier from the western wind break and the packing shed provides shelter from any winds which are North of East.

The results for sites 2 to 5 were analysed for each quadrant to find out if there was any significant difference in the wind speed reduction along the line of anemometers.

a) Winds from North

The only shelter from the North wind is provided by the other buildings. The reduction at each position was around 35% (Table IIa). The upper 95% confidence limit of the means were all less than 1. The actual reduction is probably slightly greater than 35% as the anemometer at site 6 is also slightly sheltered from winds from the North.

b) Winds from East

It was thought that a funnelling effect might occur with winds from the East but there was actually an increased reduction in wind speed along the line from E to W from 24% to 31%. A 't' test was applied to the mean values of Table IIb and there was found to be a significant difference at the 5% level between the means at sites 2 and 5 and sites 3 and 5. There was no significant difference between the means at any of the other sites. The upper 95% confidence limits were less than 1 except for that at site 2. Therefore the wind speed at site 2 is not considered to be significantly different from the wind speed in the open.

c) Winds from South

Sites 2 and 3 were situated to the north of the southernmost row of glasshouses while sites 4 and 5 were clear of this obstruction. The reduction in mean wind speeds at sites 2 and 3 was about 42% while the largest reduction, at site 5, was 60%. This is probably due to the fact that there were more occasions of wind from West of South than from South or East of South and the configuration of the shelter belt in the SW corner provides good shelter from winds from the SW at site 5. A 't' test was applied to the mean values of Table IIc and there was found to be a significant difference at the 5% level between the mean values for all sites except between site 2 and site 3. The upper 95% confidence limits of the means were all much less than 1.

d) Winds from West

The reduction in mean speed was 57% at site 5, nearest to the western edge of the wind break, and decreased to 30% at site 2 furthest from the wind break. Site 5 is approximately 4 times the height of the wind break distant from the wind break and site 2 is approximately 21 times the height of the wind break distant from the wind break. A 't' test was applied and there was found to be a significant difference at the 5% level between the means for adjacent sites in all cases. The upper 95% confidence limits of the mean values were all less than 1.

A graph was drawn of the mean ratio for the cup counter anemometers at sites 1 to 5 against the distance in heights of the shelter belt. This graph is compared with results found experimentally by Caborn (1965). The values obtained at sites 4 and 5 are reasonably close to the values obtained by Caborn but the values obtained at sites 1, 2 and 3 are much lower. Sites 1, 2 and 3 are sheltered by the other buildings except when the wind is due West while sites 4 and 5 only obtain extra shelter from that provided by the shelter belt when the winds are North of West.

Ridge anemometer

The wind speed at the anemometer sited on the ridge of glasshouse 12 was also compared with those of the outside anemometer. The anemometer on the ridge is at a height of 4.7 m and the outside anemometer at a height of 2 m. Using a logarithmic wind profile over short grass, roughness length 5 mm (McIntosh and Thom) the ratios were calculated to give an estimation of the reduction in wind speed at a height of 4.7 m (Table III). A reduction of 46% was noted with winds from the West and of 27% with winds from the South. The upper 95% confidence limits of the mean values gave a value less than 1 with winds from the West and a value of 1.07 with winds from the South. Therefore the wind speed is not considered to be significantly different from the outside wind speed with winds from the South. The shelter belt height is 3.5 m and the ridge height is 4.7 m at a distance of approximately 6 heights from the shelter belt to the South and South West. This is probably too close to the belt to give any reduction at this height while the reduction with westerly winds is due to the increased distance from the barrier.

EFFECTIVENESS OF SHELTER

From the above results it is apparent that the shelter belt and surrounding buildings now provide considerable shelter to winds from most directions. The only exceptions are at the Eastern end of the glasshouses with easterly winds and at ridge height with southerly winds. The polythene houses are protected from winds from an easterly direction by the packing shed and workshop. Due to difficulties with the cup counter anemometers there is no information for winds from North and East at ridge height.

RESUME OF MAIN POINTS

(i) Sufficient protection is provided by existing buildings to winds from the North.

(ii) There is no 'funnel' effect with winds from the East between E-W orientated houses but there is less reduction with winds from the East than with winds from all other directions.

(iii) There is a large reduction in wind speed behind the barrier with winds from the West and this reduction decreases as distance from the barrier increases.

(iv) From the above conclusions the wind break and existing outbuildings provide effective shelter to the glasshouses and polythene houses with the exception of the area between the windbreak and the boiler house where there is no protection from East winds, except possibly in the lee of houses 7, 8 and 9 (Fig 1).

REFERENCES

McIntosh D H and Thom A S (1969) - Essentials of meteorology (Wykeham Publications).

Caborn J M (1965) - Shelterbelts and windbreaks (Faber & Faber Ltd).

Any comments or suggestions on this paper should be referred to the author.

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TABLE I. Ratio or run of wind at anemometer 1 to outside anemometer.

Direction	N	E	S	W	All (inc. variables)
Mean	.47	.56	.57	.53	.54
No. of occasions	11	41	35	38	136

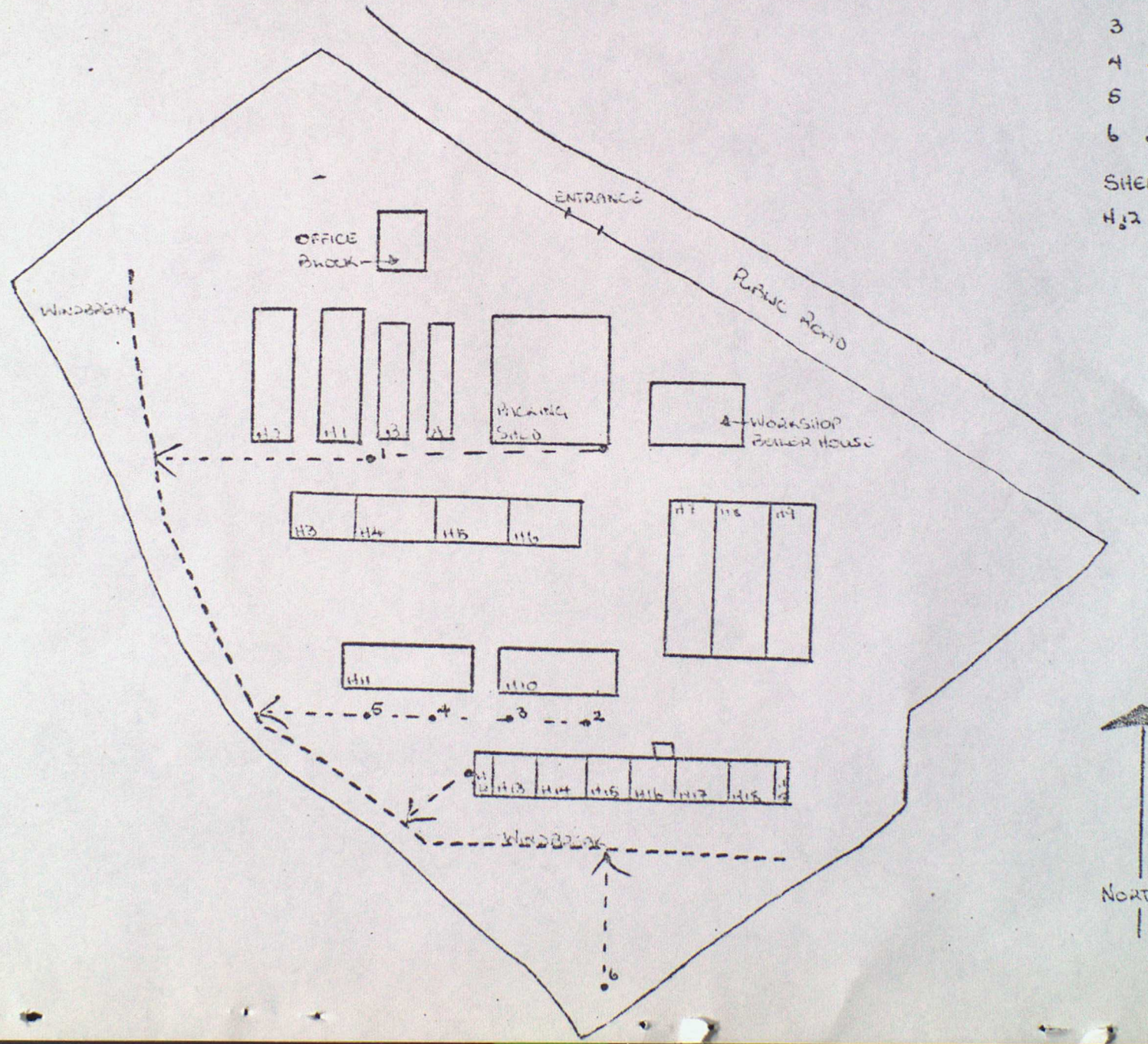
TABLE II. Ratio of run of wind at anemometers 2, 3, 4 and 5 to outside anemometer.

Direction	Anemometer	2	3	4	5
a) North 11 occasions	Mean	.65	.64	.65	.65
b) East 41 occasions	Mean	.76	.75	.71	.69
c) South 35 occasions	Mean	.58	.57	.52	.40
d) West 38 occasions	Mean	.70	.60	.53	.43

TABLE III. Ratio of run of wind at ridge site to outside anemometer. (Adjusted to give 4.7 m run of wind at both anemometer sites).

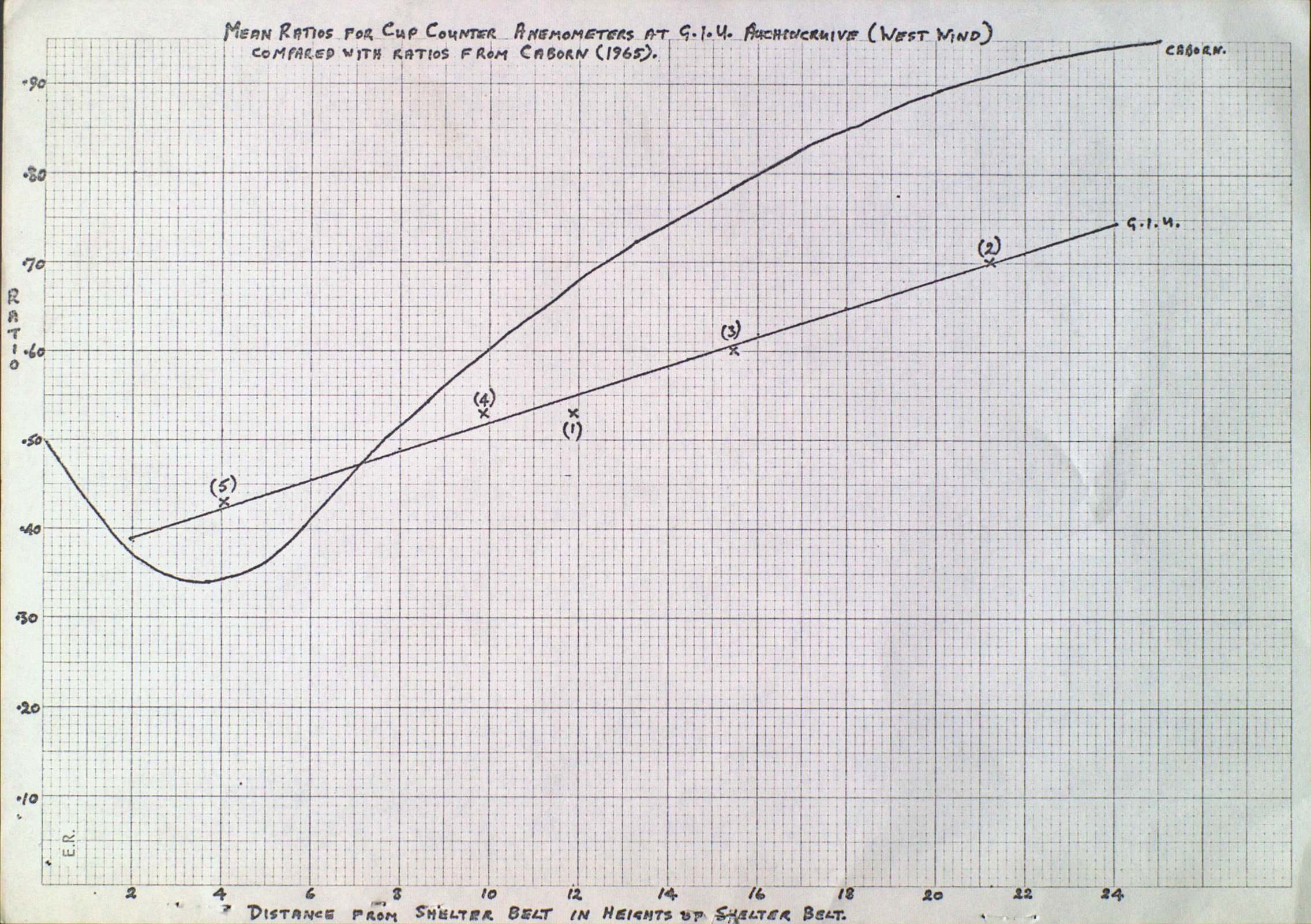
Direction	S	W
Mean	.73	.54
No. of occasions	13	19

FIG. 1. PLAN OF GLASSHOUSE COMPLEX AT C.I.U. AUCHINCRUIVE



Distance from Windbreak

1	41m	70cm
2	74m	39cm
3	54m	39cm
4	34m	23cm
5	14m	30cm
6	28m	36cm
SHED	82m	30cm
H.12	20m	96cm


MEAN RATIOS FOR CUP COUNTER ANEMOMETERS AT G.I.H. AUCHINCRUIVE (WEST WIND)
COMPARED WITH RATIOS FROM CABORN (1965).
CABORN.
G.I.H.
(1)
(2)
(3)
(4)
(5)
RATIO
·90
·80
·70
·60
·50
·40
·30
·20
·10
E.R.
2
4
6
8
10
12
14
16
18
20
22
24
DISTANCE FROM SHELTER BELT IN HEIGHTS OF SHELTER BELT.